**IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF TEXAS
HOUSTON DIVISION**

MAGĒMĀ TECHNOLOGY LLC, **Plaintiff,** **v.** **PHILLIPS 66, PHILLIPS 66 COMPANY, AND WRB REFINING LP**, **Defendants.**	**Case No. 4:20-cv-02444** **JURY TRIAL DEMANDED**

PLAINTIFF MAGĒMĀ TECHNOLOGY LLC'S TECHNOLOGY TUTORIAL

Pursuant to the Court's Scheduling Order (Dkt. No. 23), Plaintiff Magēmā Technology LLC ("Magēmā") submits the following technology tutorial discussion concerning the subject matter of the asserted patents in this case: U.S. Patent No. 10,308,884 ("the '884 Patent") (Dkt. No. 1-1); U.S. Patent No. 10,533,141 ("the '141 Patent") (Dkt. No. 1-2); U.S. Patent No. 10,604,709 ("the '709 Patent") (Dkt. No. 1-3); and U.S. Patent No. 10,584,287 ("the '287 Patent") (Dkt. No. 1-4) (collectively, "the Magēmā Patents"). For the convenience of the Court, an animated and narrated tutorial is submitted as Exhibit 1 to illustrate the technology and concepts discussed herein. The narration tracks this written submission and is intended to stand alone, if the Court would prefer only to reference Exhibit 1. For the further convenience of the Court, a written copy of the slides and narration of Exhibit 1 is provided as Exhibit 2 hereto.

I.   Introduction

The asserted claims of the Magēmā Patents include Claims 1, 2, 4-6, and 8 of the '884 Patent; Claims 1-4 of the '141 Patent; Claims 1, 2, 4, and 5 of the '709 Patent; and Claims 1, 4-8 of the '287 Patent.

The Magēmā Patents teach a low sulfur heavy marine fuel oil and processes for making the same. This fuel is intended for use in large, commercial ocean-going vessels—such as container or cargo ships—which generally have massive combustion-powered engines.

II.   Background of the Technology

Ocean-going ships have relied upon heavy marine fuel oil ("HMFO") as fuel for their large two stroke diesel engines for over 50 years. *See* Exs. 1 and 2 at Slide 7; '884 Patent at Col. 1:38-39[1]. Because re-fueling is not an option during ocean passage, these vessels also store fuel that they need in storage tanks onboard the ship for several weeks at a time. For ship engines to power the ship effectively, the fuel needs to move from the storage tanks through purification and into the chamber of an engine for combustion.

Generally, crude oil contains a mixture of hydrocarbons that refiners separate, extract, and convert into useable products using various processes. Hydrocarbons are organic chemical compounds composed of hydrogen and carbon atoms arranged in many different ways. *See* Exs. 1 and 2 at Slide 8; '884 Patent at Col. 5:10-6:17. The type of crude oil used as a feedstock to a refinery determines the products and yields of such products. At a very high level, a simple refinery typically uses atmospheric distillation to separate crude oil by boiling point into different hydrocarbon molecule fractions, including gases, naphtha, middle distillate (which includes light and heavy gas oil), and a bottoms fraction which is sometimes referred to as "residues." *See* Exs. 1 and 2 at Slide 8.

From top to bottom of the distillation tower, the fractions get heavier. Gases tend to have the simplest molecular structure, containing the fewest carbons in the molecules, whereas residues

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[1] The citations throughout are representative of the specifications of the Magēmā Patents. Similar citations may be found each of the '884 Patent, '141 Patent, '287 Patent and '709 Patent.

tend to have more complex molecules containing many more carbons. Gases have the lowest boiling point and residues have the highest boiling point. *See* Exs. 1 and 2 at Slide 8. Also, from top to bottom, the fractions increase in sulfur content, with gases at the top having the lowest sulfur content and residues at the bottom having the highest sulfur content. Each fraction has different properties that make them useful for different purposes, from gasoline for cars to heating oils and lubricants. Lighter, lower sulfur products tend to be more valuable than heavier, high-sulfur residues. Not all atmospheric distillation units operate the same way. Typically, there are five streams removed from an atmospheric distillation tower unit, although some refiners may further break down the extracted materials into additional streams such as lubricant oils and asphalt, depending on the needs of the refinery. *See* Exs. 1 and 2 at Slide 9.

The crude oil feedstock—with all of its fractions—is heated by a furnace before entering the atmospheric distillation tower. Generally, atmospheric distillation is limited to a maximum temperature of around 360°C. *See* Exs. 1 and 2 at Slide 9. Additional materials in the bottoms fraction would boil and vaporize, if the temperature were to be further increased. However, other reactions, such as coking and cracking, start to occur at temperatures above 360°C, and such reactions are not desirable at this stage of crude oil refining. Accordingly, any fractions whose boiling point is higher than 350°C remain unseparated within the residue fraction of the atmospheric distillation tower unit. *See* Exs. 1 and 2 at Slide 9.

Each stream has a range of temperatures representing a range of different hydrocarbons that comprise that fraction. *See* Exs. 1 and 2 at Slide 9. The distillation of hydrocarbons is not an exact science because different hydrocarbons may have the same or similar boiling temperatures. Different refineries will use different ranges of temperatures—which are the upper and lower "cut points", and which are optimized for the crude oil being processed. By changing the operating

temperature at which each of these streams are removed, a refiner can take different "cuts" of the feedstock. If, for example, a refiner took a first stream at an upper cut point of 280°C, it would have a bottom fraction with more heavy gas oil material in it (i.e., the bottom fraction would have a "fatter" cut) than a refiner that took the first stream off at an upper cut point at 350°C (i.e., the bottom fraction would have a "leaner" cut). *See* Exs. 1 and 2 at Slide 9.

This general principle applies to other subsequent units in a more complex refinery. By altering the operating parameters (temperature and pressure, for some units), a refiner can obtain products that have different fractions of materials. Accordingly, it is important to always consider the physical properties of the material rather than solely the name given to a material or the refinery unit from which the material is being removed.

In a more complex refinery, the streams from the atmospheric distillation unit are subjected to additional and various combinations of processes to further extract more valuable hydrocarbon products from the crude oil. *See* Exs. 1 and 2 at Slide 10; '884 Patent at Col. 5:10-6:17. Relevant here are the additional processes that allow refiners to further extract hydrocarbon products from the atmospheric tower residues. One example of such a process is vacuum distillation, wherein residues from the atmospheric distillation tower are subjected to further distillation but under reduced pressure (i.e., vacuum). *See* Exs. 1 and 2 at Slide 10; '884 Patent at Col. 5:10-6:17. This allows refiners to distill off more gas oils from the residues, without exceeding a maximum temperature of 360°C where other reactions start to occur. *See* Exs. 1 and 2 at Slide 10.

Another example is fluidized catalytic cracking ("FCC"). Cracking operates at higher temperatures in the presence of catalysts in an FCC unit to crack or break the residues from the distillation units into smaller molecules. FCC units primarily produce naphtha, but also hydrocarbons such as cycle oils and slurry oil. *See* Exs. 1 and 2 at Slide 10. Hydrocracking may

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also be used to extract from atmospheric tower bottoms lighter materials such as naphthas, diesel, and unconverted oils. *See* Exs. 1 and 2 at Slide 10. Visbreaking, which is also a form of thermal cracking, yields further gas oil components and other products. Coking is very severe thermal cracking process, and completely destroys the residues. The products of a coker unit are gases, coker naphtha, coker gasoil, and coke, which is essentially solid carbon and has no further refining value. *See* Exs. 1 and 2 at Slide 10. Conventionally, refiners remove sulfur from each product stream separately through individual and specific hydrotreater units that would hydroprocess the output of the various refinery units before finishing and blending the streams into final products to be sold. *See* Exs. 1 and 2 at Slide 10; '884 Patent at Col. 5:65-6:2.

Refiners use progressively more complex treatment units that employ catalysts and more severe process conditions, such as elevated temperature and pressure, to squeeze the most value possible out of each barrel of crude oil. As the Magēmā Patents explain, the refining industry has focused on technological advances to develop further crude oil conversion processes, with the goal to create more valuable, preferably middle distillate range hydrocarbons. *See* Exs. 1 and 2 at Slide 11; '884 Patent at Col. 5:29-36. At the same time, these crude oil conversion processes further concentrate complex, hydrocarbon molecules called "asphaltenes," as well as environmental contaminates such as sulfur, nitrogen, phosphorous, and metals into a form for removal from the refinery stream, making the residues increasingly less valuable and more difficult to use and handle. In other words, residue fractions have not been treated by refiners as a separate product for optimization, but rather, as by-products of a refinery. While some refiners have participated in making marine fuels, their objective in doing so has been to find a revenue-generating way to dispose of a refinery's residues. *See* Exs. 1 and 2 at Slide 12; '884 Patent at Col. 6:25-30.

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Residues of the various refinery processes are difficult, lower-value materials that are also expensive to further convert to a higher-value material. Usually these residues have been used in various combinations to make HMFO, with added "cutters" to achieve a desired viscosity, density, and metals content. *See* Exs. 1 and 2 at Slide 12; '884 Patent at Col. 1:40-50. Typical streams included in the formulation of HMFO are specifically described in the Magēmā Patents as including: atmospheric residues, vacuum residues, visbreaker residue, FCC Light Cycle Oil, FCC Heavy Cycle Oil, FCC Slurry Oil, heavy gas oils such as atmospheric gas oil, vacuum gas oil, and coker gas oils; delayed cracker oil (DCO), unconverted oils, and deasphalting pitch, and small portions of cutters such as cutter oil, kerosene or diesel. *See* Exs. 1 and 2 at Slide 12; '884 Patent at Col. 1:40-50.

The formulation of heavy marine fuel oil also requires knowledge of certain characteristics of the hydrocarbons that comprise the various components. An important characteristic is the paraffinic or aromatic nature of an HMFO component. *See* Exs. 1 and 2 at Slide 13; '884 Patent at Col. 4:57-62. This characteristic affects the overall stability and compatibility of an HMFO.

Paraffinic materials have more simple, straight or branched carbon chains. Paraffinic materials are fully saturated, meaning that they do not contain any double bonds between adjacent carbon atoms. Distillate materials tend to have greater paraffinic content. Aromatic hydrocarbons have complex, carbon rings. Residues tend to have a higher aromatic content. One complex type of aromatic hydrocarbon discussed at length in the Magēmā Patents is asphaltenes. *See* Exs. 1 and 2 at Slide 13; '884 Patent at Col. 1:32-37, Col. 6:4-17. Asphaltenes are large, complex hydrocarbon molecules that frequently include at least one sulfur atom embedded within the structure. Given the complex nature of these molecules, it was commonly believed that the sulfur atom was difficult to access and thus difficult to remove through hydrotreating. Asphaltenes also have attached

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paraffinic side chains. The side chains contribute to the reduced stability of asphaltene suspensions in crude oil. Asphaltenes tend to agglomerate and often become so large that they can no longer be held in suspension. When this happens they precipitate. Once precipitation occurs, the asphaltenes cannot be made soluble again. *See* Exs. 1 and 2 at Slide 13; '884 Patent at Col. 1:32-37, Col. 6:4-17. Agglomeration and precipitation of asphaltenes forms a sludge that blocks filters, reactors, pipes within refineries, and importantly, ships' fuel systems.

The crude oil conversion processes concentrate asphaltenes as well as environmental contaminates such as sulfur, nitrogen, phosphorous, and metals in residues from which HMFO is made. In fact, absent an intentional effort to remove sulfur from the residues, HMFO contains fairly large amounts of sulfur. When HMFO is combusted in a ship's engine, the reaction produces sulfur dioxide, which is a well-known pollutant. For several decades, a major global environmental concern has been acid rain and environmental damage resulting from increased levels of sulfur dioxide in the atmosphere. *See* Exs. 1 and 2 at Slide 15; '884 Patent at Col. 1:61-67.

In the 1990s, the International Maritime Organization ("IMO")—which is a branch of the United Nations—began to implement regulations with the aim of reducing emissions of sulfur dioxide from ships. IMO has adopted regulations with the goal of improving quality standards of marine fuels and to actively support the reduction of marine and atmospheric pollution. With that goal in mind, in 1997, IMO adopted what is known as the Convention for Prevention of Marine Pollution ("MARPOL") Annex VI. *See* Exs. 1 and 2 at Slide 16; '884 Patent at Col. 2:1-3:20. Annex VI went into effect in 2005 and has since progressively tightened the limits on sulfur content in heavy marine fuel oil. Initially, Annex VI capped sulfur content of HMFO at 4.50% by weight. In 2008, a revised Annex VI was adopted to take effect in 2010. Revised Annex VI mandated a global reduction of the sulfur content in HMFO from a maximum of 4.50% by weight to a

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maximum of 3.50% by weight, effective January 2012. The revised Annex VI included an even more drastic sulfur cap to take effect in January 2020 that mandated a global reduction of sulfur content in HMFO from 3.50% by weight to 0.50% by weight. This cap is referred to as "the IMO 2020 Sulfur Cap." The IMO 2020 Sulfur Cap provided one alternative to using a low sulfur HMFO. Ships could install an exhaust gas cleaning system known as "scrubber" to remove sulfur oxides from the exhaust gases prior to discharging the exhaust gases into the air.

As the Magēmā Patents explain, the IMO 2020 Sulfur Cap created a problem for both the marine industry, which needed sources of low sulfur HMFO, and the refining industry, which now needed a new way to clear their high sulfur refinery residues. *See* Exs. 1 and 2 at Slide 16; '884 Patent at Col. 6:21-46.

As explained in the Magēmā Patents, the refining industry primarily responded to the IMO 2020 Sulfur Cap in four ways: First, several refiners believed that ships would install exhaust gas scrubbers and continue using high sulfur HMFO that the ships' engines were designed to use. These refiners made few changes in response to the IMO 2020 Sulfur Cap. Scrubbers are costly to install, however, and require downtime in ports. Scrubbers further require a ship's crew to operate a new and complex chemical process unit while underway at sea. Scrubbers also generate waste material that must be stored on board the ship and disposed of at the next port. To date, the estimated portion of ships installing scrubbers is minimal. *See* Exs. 1 and 2 at Slide 18; '884 Patent at Col. 3:21-26. Second, refiners believed that they could address the IMO 2020 Sulfur Cap by using low sulfur refinery streams with residual streams. This created hybrid "franken-fuels" that do not meet the requirements to be sold as distillate marine fuels. *See* Exs. 1 and 2 at Slide 18; '884 Patent at Col. 4:40-5:9. Third, refiners believed that ship owners would turn to distillate fuel sources such as marine diesel oil ("MDO") and marine gas oil ("MGO") as their sole source of

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fuel. While these distillate fuels are more stable than the franken-fuels, the vast majority of ocean-going vessels are not equipped with engines designed to run off of distillate fuels. Further, these fuel sources are much more costly than traditional HMFO and would greatly increase the costs of shipping, potentially beyond what the shipping market would support. *See* Exs. 1 and 2 at Slide 18; '884 Patent at Col. 4:25-38. Finally, as a fourth option, refiners believed that the marine industry would turn to alternative fuel sources such as liquefied natural gas ("LNG"). LNG, however, presents serious operational challenges for ships, as it requires very low temperature storage for which most ships are not equipped, thus requiring modifications to a ship's fuel storage and fuel transfer systems. There also are relatively few LNG re-fueling sources in major global ports thus severely limiting the range of ports to which an LNG fueled ship can go. *See* Exs. 1 and 2 at Slide 18; '884 Patent at Col. 3:55-4:5.

The formulation of HMFO has always involved a blend of various refinery streams. Prior to the IMO 2020 Sulfur Cap, however, HMFO was blended to achieve a desired viscosity, density, metal content, and flash point needed for ships' engines, with minimal regard for the sulfur content. Since the effective date of the IMO 2020 Sulfur Cap, the goal of many major refiners has been to blend various refinery streams to achieve the desired sulfur content. Given the high sulfur content of residues, a much greater amount of low sulfur hydrocarbons must be added produce a fuel that meets the IMO 2020 Sulfur Cap, thereby making fuels that have been referred to as Franken-Fuels. They neither meet standard specifications for distillate fuels nor possess the qualities of the HMFO for which marine engines were designed. *See* Exs. 1 and 2 at Slide 19; '884 Patent at Col. 3:55-4:5. One reason such fuels are being made is that refiners need to clear the high sulfur by-product residues from the refinery. In other words, the refiners have no other "home" for these residues.

Franken-fuels, however, are fundamentally problematic. While such fuels are formulated to meet the requirements of various fuel specifications, they are largely composed of lighter, distillate range material. As explained above, distillates are commonly composed of paraffinic hydrocarbons, whereas residues are commonly composed of more aromatic hydrocarbons, including asphaltenes. Mixing paraffinic materials with aromatic materials is tricky and may cause asphaltenes to precipitate. Even if a blend is achieved, most are very fragile blends. Small changes in environmental conditions, such as temperature or reduced levels of mixing can cause separation of the blend into its component hydrocarbons. Over time—as these blends are stored in a ship's bunker tanks—they often are not stable and will separate.

Further, because of the delicate balance needed for these blends, re-fueling may disrupt the balance, causing hydrocarbons to separate or precipitate. In other words, the blends have serious compatibility problems, which essentially locks ships into specific suppliers. In addition, the low sulfur materials used to make Franken-Fuels are costly, resulting in an overall increase in the costs of fuel to the marine shipping industry.

The engines of large ocean-going ships are designed to combust HMFO. If a fuel is not properly formulated for this intended use, a ship's engine and fuel delivery system may be damaged. In some extreme cases, improperly formulated fuel can cause engine failures, explosions, or fires. In addition to damage to a ship, its engine and fuel delivery system, a serious concern is the risk of injury to the crew aboard a ship. Changes in temperature also may disrupt the delicate balance of Franken-Fuel blends, causing highly paraffinic components to form waxy deposits or asphaltenes to precipitate. The precipitation of asphaltenes results in difficult-to-remove sludge to form in a ships' fuel delivery system and engines. Unstable Franken-Fuels may also have variable (non-uniform) physical properties like density, viscosity and Calculated Carbon

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Aromaticity Index ("CCAI"), which results in combustion problems. Depending on where the ship is located at the time of damage, the results can be disastrous, for example, engine failure during a storm or while 1000s of miles from any shore, leaving a crew adrift and a ship endangered.

HMFO is conventionally formulated from a wide range of refinery streams that have very different physical properties and combustion profiles. To ensure that HMFO would be formulated in a way that would not damage a ship's engine or fuel delivery systems, standards were developed. Internationally, a large number of marine fuel categories are available due to variations in crude oil supplies, refining methods, ship machinery characteristics, local regulations, and other issues. The two primary standards that are used in the industry are the ASTM D396 standard and the ISO 8217 standard. *See* Exs. 1 and 2 at Slide 23-24. The patented technology focuses on HMFO formulated in compliance with ISO 8217. *See* Exs. 1 and 2 at Slide 23-24; '884 Patent at Claim 1. ISO-8217 is a specification of marine fuels promulgated by the International Organization for Standardization. It specifies a set of key properties as well as specific test methods to be used to determine those properties.

The inventors' patented solution to the IMO Sulfur Cap 2020 is unconventional and elegant in its simplicity. The conventional approach of refiners is to handle each refinery stream separately, for a variety of reasons. Therefore, refiners tend to hydrotreat individual refinery streams. Given the number of potential residue streams traditionally used to formulate an HMFO, many, costly hydrotreater units would be needed to accomplish hydrotreating of every potential residue stream. Thus only a subset of streams are usually hydrotreated. As a result, the components of HMFO remain relatively high in sulfur content, thereby requiring a greater proportion of low sulfur materials to obtain an IMO 2020 Sulfur Cap compliant fuel oil, as discussed earlier in this tutorial. The inventors, however, realized they could instead formulate an ISO 8217 compliant HMFO, and

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then hydrotreat that compliant HMFO to remove sulfur by hydrotreating under specific conditions discussed later in this tutorial. The patented process describes operating parameters that maintain the bulk physical properties of the original, high sulfur HMFO in the product, low sulfur HMFO. In doing so, the inventors unexpectedly found that the HMFO—including the asphaltenes and other becomes chemically homogenized such that the resulting product is stable and compatible with a wide range of diluents. *See* Exs. 1 and 2 at Slide 25. Given traditional refineries and their conventional approach to refining and blending, it was counterintuitive to start with an ISO 8217 compliant HMFO to produce an ISO 8217 compliant and IMO compliant HMFO.

One key to understanding the patented technology is to understand the ISO 8217 standard. Similar to the different grades of fuel at the gas station, there are different grades of marine fuel specified by ISO 8217. ISO 8217 identifies properties for both distillate marine fuels and residual marine fuels. ISO 8217 Table 1 sets forth the standards required of distillate fuels, and ISO 8217 Table 2 sets forth the standards required of residual marine fuels. *See* Exs. 1 and 2 at Slide 26.

One important requirement of a distillate fuel is that it be "clear and bright" in appearance, as opposed to "cloudy" or "dark". As shown here, a "clear and bright" fuel would be Fuels 5 and 6 on the far right. Distillates are clear and bright given the simpler molecular structure of the components as compared to more carbon-rich, heavy residues. *See* Exs. 1 and 2 at Slide 27.

For purposes of this case, the parties have agreed that the term "ISO 8217:2017 compliant" and related variations of that term means that a fuel ""meets the bulk physical properties of any of a RMA, RMB, RMD, RME, RMG, or RMK residual marine fuel as set forth in Table 2 of the ISO 8217:2017 standard." *See* Exs. 1 and 2 at Slide 28. Bulk physical properties are defined in the Magēmā Patents' specification to include density, viscosity, CCAI and flash point. *See* Exs. 1 and

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2 at Slide 29. Each of the bulk physical properties play a critical role in ensuring a fuel will work

for its intended purpose in an ocean-going ship.

Viscosity is a measure of a fluid's resistance to flow and is highly dependent on

temperature. Viscosity increases as temperature decreases. Viscosity is one of the most—if not the

most—important characteristic in the storage and use of fuel oils. It influences the temperature

required for handling and storage, and, very importantly, for fuel injection into the engine

combustion chamber. If the fuel oil is too viscous, it must be heated to be injected into the engine.

If a fuel is not viscous enough, it may need to be chilled, which can cause 'waxing.' In sum,

viscosity plays a major part in ensuring optimum storage and fuel injection efficiency. *See* Exs. 1

and 2 at Slide 30.

Density is the mass per volume at a stated temperature. Increased density will generally

correspond to an increase in energy produced by combustion for the same volume of fuel;

decreased density will generally correspond to a reduction in energy produced by combustion for

the same volume of fuel. Density also impacts the removal of fuel contaminants on-board a ship.

As the density of a fuel increases beyond the limits set forth in ISO 8217 Table 2, it is harder to

separate contaminants for removal. *See* Exs. 1 and 2 at Slide 30.

CCAI relates to how easily a fuel will ignite. It is based on a relationship between viscosity

and density, and reflects an estimate of how long the fuel will take from injection to ignition. CCAI

has important implications on the likelihood of engine damage. Usually, a fuel is mixed with hot

compressed air in an engine's cylinder and begins to vaporize, the longer the ignition delay, the

more fuel will have been injected and vaporized and the more explosive the initial combustion will

be. This also impacts the timing of the initial combustion and the duration of the combustion

process in the engine. The combustion process in engines is precisely timed to create a maximum

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amount of power and eliminate any damage to the engine itself caused by the explosive combustion process.

The flash point of a fuel is the temperature at which vapor given off will ignite when an external flame is applied. A flash point is defined to minimize fire risks during normal storage and handling. Fuels with a lower flashpoint create an increased risk of fire and explosion. The minimum flash point for marine fuels is defined by the Safety of Life at Sea Convention.

Returning to ISO Table 2, many of the physical property requirements are set forth as a maximum or minimum, which is indicated here with a "greater than" or "less than" sign.

To determine which ISO 8217 fuel grade a specific material qualifies, a laboratory will run the required tests on a sample and generate a report reflecting the sample's physical characteristics. Each of the physical characteristics of the sample is compared to the requirements in Table 2 of the ISO 8217 standard. An example of this comparison is illustrated in Slide 32. As shown in Slide 32, a sample must meet each of the requirements of a specific fuel grade within Table 2 to be sold as any grade for which it meets each requirement. Here, the sample meets the requirements for only RMK 500 and RMK 700. *See* Exs. 1 and 2 at Slide 32.

Generally, if a sample meets the specification for more than one fuel grade, fuel traders will sell the material as the most valuable grade for which the material qualifies. The fuel grades decrease in value as you move from left to right across the columns on Table 2; thus, generally, an RMA is more valuable than an RMK.

Hydrotreaters are commonly used to remove sulfur and other metal contaminants. Hydrotreaters include at least one catalyst reactors and various other units to further separate products. One example of a hydrotreater that may be used to carry out the steps of the patented processes—such as Asserted Claim 1 of the '141 patent—is illustrated in Figure 1 of the Magēmā

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Patents. As illustrated in Fig. 1, a high sulfur feedstock HMFO (2) is mixed with activating gas (4). The the Magēmā Patents define "Activating Gas" as including mixtures of nitrogen, hydrogen, carbon dioxide, gaseous water, and methane. The mixture is then contacted with one or more catalysts within the reactor (8). Then, the resulting process mixture is then feed to a separator unit 12 that separates liquid components 14 from gas components 16. Finally, the Liquid Components 14 are then sent to a third unit 18 which may be a stripper or other unit that separates any remaining gas components 20 and by-product hydrocarbon components 22 to produce low sulfur, Product HMFO 24. *See* Exs. 1 and 2 at Slide 33; '884 Patent at Col. 8:44-11:17. Asserted dependent claims of the '141, '709, and '287 Patents further recite temperatures, pressures, catalysts, and other operating parameters for the Reactor.

A catalyst is a material that is used to facilitate a reaction. Here, the catalysts are selected to aid the removal of sulfur and other metal contaminants. The Magēmā Patents describe the preferred transition metal catalysts as Nickel-molybdenum (also referred to as "Molly"); cobalt-Molly; nickel-tungsten, or nickel-cobalt-molly. *See* Exs. 1 and 2 at Slide 34; '141 Patent 7:24:37.

The catalysts are dispersed as a thin particle layer over the entire surface and pores of a porous inorganic catalyst carrier. This thin transition metal layer is invisible to the naked eye. Different catalysts have different activity. Some are more reactive than others, and some are designed to have a preference for demetalization or desulfurization reactions. The choice of catalyst will be driven by the specific components of the HMFO feedstock that is being hydrotreated. *See* Exs. 1 and 2 at Slide 34; '141 Patent 7:24-37.

The catalysts are dispersed on porous inorganic oxide carriers. These carriers come in a wide variety of shapes and sizes and have microscopic pores that further increase the surface area where the catalyst reactions may occur. *See* Exs. 1 and 2 at Slide 35; '141 Patent 7:17-24.

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The Magēmā Patents describe several different arrangements of the catalysts and carrier within the catalyst reactor. *See* Exs. 1 and 2 at Slide 36. These include fixed bed reactors, ebullated or fluidized bed reactors, structured bed reactors, and others. Often, the catalysts and carriers will be packed in several beds. Figure 2 of the '141 Patent shows an example of a catalyst reactor with three beds, highlighted in green. Within each bed, there may be several layers of carriers of varying sizes and loaded with varying catalysts. In a fixed bed configuration, the liquid mixture moves through the beds, from top to bottom, reacting with the catalyst as it moves through the reactor. The Magēmā Patents further describe a catalyst packing scheme preferential to desulfurization wherein the first bed is packed with a catalyst preferential to demetalization, followed by a bed of catalyst with mixed activity for demetalization and desulfurization, followed downstream by a catalyst bed with high desulfurization activity. *See* Exs. 1 and 2 at Slide 36; '141 Patent at Col. 15:9-14.

In addition to the removal of sulfur and other contaminants, hydrotreating typically involves—to some extent—both hydrocracking and hydrogenation reactions. Hydrocracking is the physical breakdown of large hydrocarbons into smaller, simpler hydrocarbons by breaking carbon to carbon bonds, and hydrogenation is the addition of hydrogen atoms to the hydrocarbons. *See* Exs. 1 and 2 at Slide 37.

Refiners typically seek to maximize uplift of their residue streams through hydrotreating. This involves the maximization of hydrocracking and hydrogenation to produce a greater fraction of smaller, simpler hydrocarbons, including naphtha and middle distillates in addition to removal of the sulfur and metals. In contrast, because the inventors sought to maintain the bulk physical properties of the HMFO feedstock. Reactions that break down the components of HMFO into naphtha and middle distillates are undesirable. Instead, the Magēmā Patents teach hydrotreating to

minimizing hydrocracking and hydrogenation, while selectively removing sulfur, nitrogen and other contaminants. *See* Exs. 1 and 2 at Slide 37; '141 Patent at Col. 17:65-18:10.

Asserted Claim 5 of the '884 Patent in particular covers a low sulfur hydroprocessed HMFO blend, wherein a majority of the blend is hydroprocessed low sulfur HMFO product and the minority of the blend is diluents. *See* Exs. 1 and 2 at Slide 38; 884 Patent at Claim 5. The patented process of hydrotreating high sulfur HMFO reorients asphaltenes molecules in the high sulfur HMFO and makes them more stable through desulfurization and demetalization reactions. In addition, hydrotreating unexpectedly makes the HMFO substantially chemically homogenous. As a result, the hydroprocessed HMFO is more uniform and stable.

Because of this and in contrast to Franken-Fuels, the patented low sulfur, hydroprocessed HMFO product is compatible with a wide range of other hydrocarbon materials, including paraffinic hydrocarbon materials. There are several reasons that a refiner, fuel trader or other market participant may desire to add diluents to the low sulfur hydroprocessed HMFO product, including to increase the volume of material for sale, which is referred to as "swelling" the product or to alter the bulk physical properties, for example, to make RMK 380 qualify as a more valuable RMG 380. Blending with the patented low sulfur hydroprocessed HMFO product does not produce a fragile, unstable blend prone to separation and precipitation such as that observed with Franken-Fuels. As recited in Claim 5, the majority of the blend must be low sulfur hydroprocessed HMFO product.

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Dated: April 2, 2019   Respectfully submitted,

By: */s/ Miranda Y. Jones*
    Miranda Y. Jones
    Attorney in Charge
    Texas Bar No. 24065519
    Southern District ID No. 1147635
    Ray Torgerson
    Texas Bar No. 24003067
    Southern District ID No. 22846
    Erin C. Villaseñor
    Texas Bar No. 24072407
    Southern District ID No. 1114483
    PORTER HEDGES LLP
    1000 Main Street, 36th Floor
    Houston, TX 77002
    Telephone: 713-226-6000
    Facsimile: 713-228-1331
    MirandaJones@porterhedges.com
    RTorgerson@porterhedges.com
    EVillaseñor@porterhedges.com

    Attorneys for Plaintiff
    Magēmā Technology LLC

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CERTIFICATE OF SERVICE

The undersigned hereby certifies that on April 2, 2021, a copy of the foregoing was filed

electronically through the Court's CM/ECF system. In addition, an electronic copy of Exhibit 1

has been served via mail upon counsel for Defendants at their mailing address listed below:

Charles B. Walker, Jr.
Mark F. Eberhard
NORTON ROSE FULBRIGHT US LLP
Fulbright Tower
1301 McKinney, Suite 5100
Houston, Texas 77010-3095

Attorneys for Defendants

/s/ Miranda Jones
Miranda Y. Jones

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